# THE IMPACT OF SOCIOECONOMIC STATUS AND RACE-ETHNICITY ON DENTAL HEALTH

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**ABSTRACT:** *This article examines the impact of race-ethnicity on dental health and the extent to which socioeconomic status (SES), routine dental care, and health-related behaviors mediate this relationship. The data used in this analysis are from the National Education and Health Survey III, a large national data set that incorporated professional dental examinations and personal interviews. Results indicate that both race-ethnicity and SES are independently and significantly related to the number of decayed and missing tooth surfaces observed in dental examinations. The authors find that Blacks are consistently the group most likely to have decayed and missing teeth, followed by Mexican Americans. Although a portion of the effects of race-ethnicity are mediated by SES, a portion of the effects of SES are mediated by smoking, sugar consumption, and dental care. The direct effects of both race-ethnicity and SES are significant, even when controlling for the effects of health-related behaviors and other key demographic factors. The effects of race-ethnicity and SES also persist when the sample is restricted to specific income and race-ethnicity groups.* Keywords: oral health; dental health; race-ethnicity; socioeconomic status.

A large body of literature has documented strong and consistent relationships between socioeconomic status (SES), race-ethnicity, and both morbidity and mortality (Coburn and Pope 1974; Hayward et al. 2000; Ross and Wu 1995). Whites have better health than racial-ethnic minorities, especially African Americans. A substantial part of this advantage is generally thought to reflect differences in social class. In spite of the pervasive cultural images associating poor dental care with poverty, very little of this research has focused on dental and oral health. This omission is surprising given the relationship of oral health to other health conditions and its influence on psychological, economic, and social well-being.[1]

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Oral health is frequently an indicator of general health status and can directly affect the probability of contracting various conditions, including coronary heart disease (Karow 2001). Impaired dentition can affect food choice, such as the avoidance of fruits and vegetables that are harder to consume, which in turn can influence the probability of developing a variety of conditions (Rugg-Gunn and Nunn 1999; Schoenberg and Gilbert 1998). Beyond these physical correlates, dental health can have a strong impact on social and psychological well-being. Attractive dentition can promote positive social interactions, as those with impaired dentition may avoid laughing, engaging in conversations, and meeting people. Through its association with general attractiveness, good dentition is believed to be related to social mobility as well as economic and social success (Chavers et al. 2002; Chen and Hunter 1996; Linn 1966; Rugg-Gunn and Nunn 1999).

Unlike a number of physical conditions, decayed teeth can be repaired so that underlying health problems are no longer apparent. In contrast to conditions such as arthritis and diabetes, which can respond to treatment but do not disappear, carious teeth can be filled and missing teeth can be replaced, often with materials that make repairs virtually invisible to the casual eye. Such repairs, of course, rely on professional dental treatment, and the less visible repairs require more costly interventions. While the general literature on the relationship between SES and health would lead us to expect SES- and racial-ethnic-based differences in total caries experience, defined as the number of decayed teeth experienced throughout a lifetime, we expect even stronger differences resulting from untreated dental problems and from treatments that are more visible (e.g., extractions rather than fillings and/or replaced teeth). It is untreated dental problems, and the more visible treatments (e.g., extraction), that are most likely to affect physical, social, and economic well-being.

This article examines the impact of race-ethnicity and SES on dental health and the ways in which health-related behaviors and regular dental care may mediate this relationship. In this analysis, dental health is operationalized in two ways: as decayed tooth surfaces and as missing tooth surfaces.[2] In this study we use information from a large national data survey, the National Education and Health Survey III (NHANES III). The NHANES III gathered data through professional dental examinations as well as extensive personal interviews regarding demographic characteristics and health care practices.

## RELATED LITERATURE

A number of studies have documented differences in dental health related to SES, with some suggesting that the differences are greater for untreated caries than for total caries experience. These differences are often explained by the fact that the poor and those with less education are less likely than others to seek preventive dental care or to have access to dental services when they are needed (Atchison and Gift 1997; Bor et al. 1993; Brown et al. 1999, 2000a, 2000b; Chen and Land 1990; Faggiano et al. 1999; Feinstein 1993; Gilbert, Duncan, and Vogel 1998; Gilbert, Duncan, and Shelton 2003; Gilbert, Shelton, Chavers, and Bradford 2003; Gillcrist et al. 2001; Kassab et al. 1996; Poulton et al. 2002; Vargas et al. 1998; Watson et al. 1998).

Theories regarding socioeconomic differences in general health status point to the role of differential access to medical care (Williams 1990), and a number of studies of dental health cite insurance coverage and the perceived ability to pay as prompting the use of dental services (Chen and Land 1990; Kassab et al. 1996; Strickland and Strickland 1996; Watson et al. 1998). But studies of general physical health as well as mortality statistics indicate that access to medical care is far from sufficient in explaining socioeconomic inequalities, for they persist in societies that have socialized medicine and appear when access to treatment is factored into the analysis (Robert and House 2000). Although this may be less true with dental health, the data are far from conclusive. One study in New Zealand, which provides universal and comparable dental care to children in all income groups, found no significant relationship of SES (measured by income, occupation, and education) to dental symptoms or functioning (Chen and Hunter 1996); other studies in the same country did find a significant relationship (Poulton et al. 2002; Treasure and Dever 1994). Countries in which socialized medical plans do not cover dentistry, or provide less than complete dental coverage, continue to have variations in dental health by SES (Hjern and Grindefjorn 2000; Faggiano et al. 1999).

Dental health status is also related to routine dental care and health-related behaviors. Authorities generally point to diet, especially the consumption of highly sugared products; regular brushing; and the use of fluoride (especially among children) as important variables. Receiving regular dental care is also important for restoring damaged or decayed teeth and for halting the spread of dental disease. Studies of general health practices find that those in lower socioeconomic groups tend to have less healthy habits and behavior; they smoke more, exercise less, and have poorer diets. These factors, however, are not sufficient to account for the relationship between social class and health (Preston and Taubman 1994). Some studies, both in the United States and in other countries, have documented the poorer oral health habits of those in the lower socioeconomic strata (Bor et al. 1993; Chen 1986; Faggiano et al. 1999; Gilbert, Duncan et al. 2003; Gilbert, Shelton et al. 2003; Rugg-Gunn and Nunn 1999), but Faggiano et al.'s (1999) study of Italian children found that even when hygiene and dietary habits were controlled, those with lower SES were more susceptible to caries.

As expected, given the strong differences in SES between racial-ethnic groups, members of minority groups tend to have poorer dental health, and especially more untreated caries, than the White majority (Atchison and Gift 1997; Brown et al. 1996,; Brown et al. 1999, 2000a, 2000b; Gilbert, Duncan, and Vogel 1998; Gilbert, Duncan et al. 2003; Gilbert, Shelton et al. 2003; Vargas et al. 1998). Studies of general health report significant variation between minority groups. For instance, examinations of infant mortality find that African Americans and Native Americans generally have the worst outcomes, whereas Asians and Pacific Islanders have the best outcomes. Hispanics and non-Hispanic Whites have similar outcomes, although strong variation exists among the various subgroups within the Hispanic community, with Puerto Ricans having the highest rates of infant mortality (Williams and Collins 1995:359). Hispanics are often found to have better health outcomes, as measured by mortality and rates of chronic illness, than would be expected given their SES, although the advantages are stronger for

recent immigrants (Williams and Collins 1995:368–9). Such differences are, in part, a function of the relatively young age of these groups.

The extent to which SES can account for race-ethnic variations in dental health is unclear. For instance, a study using a small convenience sample of women in one community found that the relationship between race and regular dental care was not significant when education, income, and insurance coverage were controlled (Watson et al. 1998). In contrast, a study of older African Americans and Whites found that African Americans were significantly more likely than Whites to experience the loss of a tooth, even when SES and dental visits were controlled (Gilbert, Duncan et al. 2003). The literature on the extent to which variables such as income, education, and access to insurance can account for race-ethnic differences in general health is also divided. Some suggest that SES can explain most of the variation in health observed between racial-ethnic groups, whereas others suggest that it can explain only part of this difference. In a recent study, also using the NHANES III data, Reid et al. (2004) found that controlling material factors greatly reduced race-ethnic differences in tooth decay. In contrast, controlling for behavioral factors had very little impact. This analysis was limited, however, by the use of binary measures of both dental decay and the independent variables and by potential problems with endogeneity resulting from the inclusion of a measure of missing teeth as a predictor of caries.

Race-ethnicity and socioeconomic disadvantage may also interact with one another to put economically disadvantaged members of minority groups, especially African Americans, at even greater risk. Although the possibility of interaction effects on overall health between demographic characteristics and SES has also been noted, these effects have not been tested in an analysis of dental health. For instance, there is some evidence of an interaction effect of SES and sex, with a smaller effect of SES for women than men (Hibbard and Pope 1991; Robert and House 2000). Previous research suggests that age may interact with both race and SES in its effect on health, although the direction of the effect is unclear. The effects of being economically disadvantaged, especially from minorities, may increase at older ages as cumulative effects become more apparent. Other research, however, indicates that the effects of SES might be weaker at older ages (Williams and Collins 1995).

Overall the available literature provides a number of hypotheses that guide our work. First previous research suggests that both race-ethnicity and SES influence dental health and that at least some of this influence occurs through the effect of these variables on access to dental care and health-related behaviors. We explicitly examine the effect race-ethnicity and two key indicators of SES, income and education, have on dental health and the extent to which mediating variables convey these effects. Including both income and education enables us to tease out the ways in which SES and education influence dental health: through access to resources, which is likely to be more related to income, or through lifestyle and health-related behaviors, which is more likely to be related to education. Including mediating variables in our models allows us to examine the possible causal pathways between race-ethnicity, SES, and dental health. To the extent that dental care and health-related behaviors mediate the effects of race-ethnicity and SES, the direct effects of race-ethnicity and SES on dental health should diminish when dental care and health-related behaviors are included in the model. Second, based on previous

research (cf., Gilbert, Duncan et al. 2003), we expect that Mexican Americans will have more untreated decay than other race-ethnicity groups and that African Americans will have more untreated decay and missing teeth than the White majority. The extent to which racial-ethnic differences can be accounted for by SES is open to question, and we examine this question. Third the literature raises a number of possible hypotheses regarding interaction effects of SES, race-ethnicity, age, and gender on dental health. The direction of these effects varies from one study to another, and thus we have no clear expectations regarding the nature of these effects.

To be most effective, an examination of the relationship of SES and race-ethnicity to dental health should (a) use a nationally representative sample, (b) employ sound multivariate analytic techniques, and (c) use valid, professionally obtained measures of dental health. Our study meets each of these criteria. In addition, our study explicitly compares the relative influence of race-ethnicity and socioeconomic status on both untreated dental decay and missing teeth, which often result from dental patient respondents receiving less expensive (and more drastic) forms of treatment. And finally our study explores the role of health habits and behaviors in mitigating the influence of SES and race-ethnicity as well as possible interaction effects.

## DATA AND METHODS

Our data come from the NHANES III (1988 to 1994). The NHANES survey is a nationwide study conducted by the National Center for Health Statistics. The sample was selected using a complex, stratified, multistage probability design, beginning with the selection of individual counties. Mexican Americans and African Americans were oversampled to allow for more accurate comparisons between racial-ethnic groups. Data were gathered through personal interviews in respondents' homes and through dental examinations in a mobile examination center. Numerous checks for intra- and interexaminer reliability were conducted throughout the study (Drury et al. 1996; Winn et al. 1996). Our analysis uses the adult survey, which includes individuals seventeen years of age and older.

### Measures

The most common way of measuring dental health within the dental literature is through counts of decayed, missing, or filled dental surfaces or teeth. Preliminary results indicated that results were virtually identical whether we examined teeth or surfaces, and we have only included the results for surfaces. Studies of dental health frequently report on the total number of decayed, missing, filled, and replaced surfaces (DMFS). DMFS is a measure of caries experience or caries history; it is not a measure of dental health. As a total composite of caries experience, DMFS is not quantitatively meaningful. For example, a person with twenty decayed tooth surfaces can have the same DMFS score as someone who has twenty filled surfaces. Because the measure has no inherent ranking or ordinality, it is not appropriate for inclusion in statistical analysis.

In this analysis we isolate two components of DMFS: (a) the number of decayed surfaces (DS), an indicator of untreated caries, and (b) the number of missing

surfaces (MS).[3] MS is an indicator of treatment that is less expensive, but more drastic, than fillings. It can also be a visible indicator of previous dental problems. There are a total of 128 tooth surfaces in the adult mouth. Including both measures of both DS and MS allows us to explicitly examine the ways in which race-ethnicity and SES are related to untreated caries and poor dental treatment. As previously noted , using less-than-optimal dental treatment (through the use of extraction rather than filling and measured by MS) and/or having untreated dental conditions (measured by DS) are likely to have negative impacts on individuals' well-being and may be related to other forms of social disadvantage.[4]

We have two measures of SES: family income, which is measured as the ratio of family income to the federal poverty level, and education, which is measured by the highest level of schooling completed. We examine the effects of three levels of educational attainment: less than high school, some college, and a college degree (with high school as the reference group). Race-ethnicity is measured by dummy variables for three minority groups: Blacks, Mexican Americans, and Other, with Whites serving as the omitted category. We also include a dummy variable indicating whether the interview was conducted in a language other than English. This may provide some indication of how recently a participant may have immigrated to the United States and the participant's level of access to the U.S. medical care system. Dummy variables are included for gender (l = *female*), rural/urban residence (l = *rural*), and region of the country (l = *South*). Age is measured in years. To control for generational differences in dental care, we present descriptive information separately for respondents sixty-five years and older and those younger than sixty-five. Multivariate analyses are restricted to those younger than sixty-five.

Three measures of health-related behaviors are included. Smoking status is measured by two dummy variables, one indicating that the participant currently smokes and another indicating that the participant smoked in the past but not in the present. Alcohol intake is measured by the number of alcoholic beverages consumed per month. Sugar consumption is measured by the number of desserts, sweets, and sweet beverages consumed per month.[5] Dental care is measured by whether the participant sees a dentist at least once a year.

## Analysis

Our independent variables include control variables for age, sex, and region; dummy variables for the race-ethnicity and education categories; and the indicators of health habits and health care. We also include a measure of family income, expressed as the ratio of the family's income to the federal poverty threshold for that family. Because the dependent measures are counts of tooth surfaces (either decayed or missing) that have a highly skewed distribution, we employ weighted Poisson regression.[6] The models used in our analysis are represented by the following equation:

$$Ln(\lambda) = \gamma_0 + \sum_{q=1}^{Q} \gamma_q X_q. \quad (1)$$

The dependent variable, $Ln(\lambda)$, is the log of the conditional rate of the count of tooth surfaces (either decayed or missing) for the individuals who share a specific vector of characteristics, $\gamma_0$ is the equation intercept, $\gamma_q$ refers to the Poisson regression coefficients associated with each independent variable, and $X$ is a set of $q$ independent variables. The exponentiation of the coefficients in this model, $EXP(\gamma)$, represents a factor score change in the surface count associated with a one unit change in the independent variable, net of other variables in the equation. The coefficients can also be expressed as a percentage change using the conversion formula $(EXP(\gamma_q)–l) * 100$.

We begin the analysis by providing descriptive statistics on all the variables in analysis stratified by age group. Next we present the means of our dependent measures by race-ethnicity and age group. In our multivariate analysis, we examine three cumulative models for both dental health outcomes: (a) a weighted Poisson regression of our measure of dental health (DS) and our measure of the effects of low-cost dental care (MS) on the measures of race-ethnicity and demographic controls; (b) a second model that adds measures of educational attainment and income, which allows us to examine the extent to which race-ethnic differences in dental health are explained by variations in SES; and (c) a third model that includes measures of health-related behaviors and routine dental exams, which allows us to examine the extent to which race-ethnic and SES differences in dental health can be accounted for by differences in these behaviors. Finally, focusing only on untreated DS, we examine interactions related to SES and race-ethnicity found in the analysis of other health areas by repeating the analysis within income and race-ethnicity subgroups.

## RESULTS

### Descriptive Statistics

Table 1 gives descriptive statistics, weighted and unweighted, for all variables used in our analysis for participants younger than sixty-five and for those participants sixty-five and older. The results indicate that all variables have sufficient variation for inclusion. Most important, there are substantial proportions of both African Americans and Mexican Americans and substantial variation in SES. The measures of dental health (DS) and dental treatment (MS) can vary from 0, indicating perfect dental health, to 128, indicating decay or extraction of all dental surfaces. Whites, Blacks, and Mexican Americans are each represented in the younger than sixty-five sample in roughly equal proportions. It is not surprising that the weighted means show that the younger respondents have more DS but older respondents have more MS. Table 1 also shows that the younger respondents are better educated and more affluent. Smoking is much more prevalent among the young, but the combination of past and present smoking is equivalent in both groups. Young respondents consume more sugar and are more likely to have annual dental care than the older respondents.

Table 2 compares the distribution of DS and MS by race-ethnicity for the two age groups. Among respondents younger than sixty-five, Whites have the fewest

**TABLE 1**

Descriptive Statistics by Age Group

| | *National Health and Education Study III* | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Age 17 to 65*[a] | | | | | | *Age 65 and Older*[b] | | | | | |
| | | | *Unweighted* | | *Weighted* | | | | *Unweighted* | | *Weighted* | |
| | *Min.* | *Max.* | *M* | *SD* | *M* | *SD* | *Min.* | *Max.* | *M* | *SD* | *M* | *SD* |
| Decayed tooth surfaces | 0 | 91 | 2.34 | 5.87 | 1.62 | 5.04 | 0 | 75 | 1.96 | 6.40 | 1.13 | 4.40 |
| Missing tooth surfaces | 0 | 128 | 8.74 | 15.50 | 6.71 | 13.22 | 0 | 128 | 14.36 | 26.14 | 10.46 | 20.65 |
| Age | 17 | 64 | 37.06 | 13.34 | 37.26 | 12.56 | 65 | 90 | 74.83 | 6.81 | 73.42 | 6.38 |
| Female | 0 | 1 | 0.55 | | 0.52 | | 0 | 1 | 0.54 | | 0.59 | |
| White | 0 | 1 | 0.34 | | 0.74 | | 0 | 1 | 0.63 | | 0.86 | |
| Black | 0 | 1 | 0.33 | | 0.12 | | 0 | 1 | 0.19 | | 0.08 | |
| Mexican American | 0 | 1 | 0.29 | | 0.06 | | 0 | 1 | 0.15 | | 0.02 | |
| Other | 0 | 1 | 0.05 | | 0.09 | | 0 | 1 | 0.03 | | 0.04 | |
| Non-English interview | 0 | 1 | 0.16 | | 0.06 | | 0 | 1 | 0.11 | | 0.03 | |
| Rural | 0 | 1 | 0.49 | | 0.50 | | 0 | 1 | 0.63 | | 0.57 | |
| South | 0 | 1 | 0.45 | | 0.36 | | 0 | 1 | 0.43 | | 0.29 | |
| High school | 0 | 1 | 0.36 | | 0.22 | | 0 | 1 | 0.56 | | 0.43 | |
| Less than high school | 0 | 1 | 0.33 | | 0.34 | | 0 | 1 | 0.23 | | 0.29 | |
| Some college | 0 | 1 | 0.18 | | 0.22 | | 0 | 1 | 0.11 | | 0.14 | |
| College degree | 0 | 1 | 0.13 | | 0.22 | | 0 | 1 | 0.10 | | 0.14 | |
| Income to poverty ratio | 0 | 11.29 | 2.36 | 1.78 | 3.12 | 1.94 | 0 | 11.889 | 2.38 | 1.84 | 2.87 | 1.99 |
| Dentist once per year | 0 | 1 | 0.40 | | 0.51 | | 0 | 1 | 0.32 | | 0.41 | |
| Smoker | 0 | 1 | 0.29 | | 0.30 | | 0 | 1 | 0.13 | | 0.12 | |
| Past smoker | 0 | 1 | 0.18 | | 0.22 | | 0 | 1 | 0.37 | | 0.40 | |
| Sugar consumption | 0 | 730 | 43.13 | 47.12 | 39.50 | 44.31 | 0 | 305 | 25.44 | 27.25 | 24.77 | 26.21 |
| Alcohol consumption | 0 | 541 | 7.52 | 18.16 | 8.40 | 17.62 | 0 | 367 | 6.30 | 19.61 | 8.29 | 22.99 |
| (a) Unweighted $N$ = 1,0418 | | | | | | | | | | | | |
| (b) Unweighted $N$ = 2,829 | | | | | | | | | | | | |

a. Unweighted $N$ = 10,418.

b. Unweighted $N$ = 2,829.

**TABLE 2**
Mean Decayed Surfaces and Missing Surfaces by Race-Ethnicity and Age[a]

| | *Age 17 to 65* | | *Age 65 and Older* | |
|---|---|---|---|---|
| | *Decayed* | *Missing* | *Decayed* | *Missing* |
| White | 1.30 | 5.75 | 0.90 | 9.61 |
| Black | 3.33 | 12.25 | 2.91 | 20.07 |
| Mexican American | 2.23 | 5.80 | 3.31 | 17.62 |
| Other | 1.71 | 8.12 | 1.56 | 7.04 |
| All respondents | 1.62 | 6.71 | 1.13 | 10.46 |
| Unweighted *N* | 10418 | 10418 | 2829 | 2829 |
| Ratio to non-Hispanic Whites | | | | |
| Black | 2.56 | 2.13 | 3.23 | 2.09 |
| Mexican American | 1.72 | 1.01 | 3.67 | 1.83 |
| Other | 1.32 | 1.41 | 1.74 | 0.73 |

a. Estimates are weighted.

number of DS and MS, followed by Mexican Americans. Blacks have the greatest number of both DS and MS. The lower means of Mexican Americans relative to Blacks for the younger than sixty-five population reflects, at least in part, the lower average age of the Mexican American population. For those sixty-five and older, we find that Mexican Americans have more DS than Blacks. The gap between Whites and Mexican Americans with MS is also much greater. Thus, by restricting the sample to those at the end of the age distribution, we reduce the effects of youth, which characterize the Mexican American population relative to Blacks. The second panel of Table 2 gives the ratio of the values for the minority groups to those for Whites. Blacks younger than sixty-five have two and a half times as many DS and twice as many MS as Whites. Mexican Americans sixty-five and older have more than three and a half times as many DS and twice as many MS as similarly aged Whites.

Thus we find that age is strongly related to both declining dental health as well as race-ethnicity, with minority groups tending to have much younger age distributions than Whites. A more appropriate examination of race-ethnic differences in dental health should therefore control for age, which we do in our multivariate analysis. The multivariate models that follow examine the extent to which race and ethnic differences persist in DS and MS, net of other variables. We are particularly interested in the extent to which these differences can be explained by the variations in SES, routine dental care, and health-related behaviors.

## Explaining Variations in Dental Health

Table 3 presents weighted Poisson regressions of DS and MS on race-ethnicity, SES, annual dental care, health-related behaviors, and the various controls. The models for DS and MS are presented in three stages. By entering the blocks of variables into the model sequentially, we can gauge the extent to which the effects

**TABLE 3**

Weighted Poisson Regression of Decayed Tooth Surfaces and Missing Tooth Surfaces on Race-Ethnicity, Poverty Status, Education, and Mediating Variables

| | *Respondents Ages 17 to 65* | | | | | |
|---|---|---|---|---|---|---|
| | *National Health and Education Study III* | | | | | |
| | *Decayed* | | | *Missing* | | |
| | *Model 1* | *Model 2* | *Model 3* | *Model 4* | *Model 5* | *Model 6* |
| Intercept | 0.3445 | 1.2474*** | 0.9883*** | –0.0096 | 0.6488*** | 0.4278* |
| Age | –0.0061* | 0.0000 | 0.0021 | 0.0383*** | 0.0387*** | 0.0398*** |
| Female | –0.3085** | –0.3559*** | –0.2157* | –0.0976 | –0.1399** | –0.0845 |
| Black | 0.9041*** | 0.4278*** | 0.4210*** | 0.8664*** | 0.5844*** | 0.5731*** |
| Mexican-American | 0.2930* | –0.1077 | 0.0304 | 0.1200 | –0.1038 | –0.0462 |
| Other | 0.1663 | –0.0915 | 0.0429 | 0.4345** | 0.3155* | 0.3602** |
| Non-English Interview | 0.5207*** | –0.1107 | –0.1802 | 0.2413 | –0.1474 | –0.1343 |
| Rural | 0.2829* | 0.0281 | 0.0228 | 0.3010** | 0.1398 | 0.1345 |
| South | 0.3294* | 0.2346 | 0.1758 | 0.1561 | 0.1075 | 0.1014 |
| Less Than High School | | 0.3733 | 0.2918** | | 0.1453* | 0.1127 |
| Some College | | –0.4418*** | –0.2210 | | –0.2727*** | –0.2201** |
| College Degree | | –1.0744*** | –0.7491*** | | –0.8143*** | –0.7214*** |
| Income to Poverty Ratio | | –0.2682*** | –0.1727** | | –0.1124*** | –0.0899*** |
| Dentist Once per Year | | | –1.0705*** | | | –0.1762*** |
| Smoker | | | 0.4268*** | | | 0.3086*** |
| Past Smoker | | | –0.3145* | | | 0.0397 |
| Sugar Consumption | | | 0.0014 | | | 0.0008 |
| Alcohol Consumption | | | –0.0010 | | | –0.0006 |

*Note:* $N$ = 10,418 for all models. Models are adjusted for design effects and unequal probability of selection.
*$p < 05$, **$p < 01$, ***$p < .001$.

of race-ethnicity and SES are mediated by the other variables in the model. The dependent variable in the first set of models (Model 1 to Model 3) is the number of DS; the dependent variable in the second set of models (Model 4 to Model 6) is MS. In both sets of models, we use only the younger sample, sixty-five and younger, to retain sufficient power for the multivariate analysis. Model 1 includes measures of race-ethnicity as well as the control variables for gender, age, language used in the interview, and measures for Southern and rural residence. Model 2 adds educational attainment and the ratio of family income to the poverty threshold. Finally Model 3 adds the measures of health-related behaviors and routine dental care. Models 4 to 6 replicate Models 1 to 3 using MS as the dependent variable.

Examination and comparison of the coefficients in Model 1 reveal that Blacks and Mexican Americans have more DS than Whites, with Blacks having a greater degree of dental morbidity than Mexican Americans, net of controls for age, sex, language used in the interview, rural residence, and region. The effect of race-ethnicity for Mexican Americans disappears, however, when SES, dental care, and health-related behaviors are added to the model (Models 2 and 3). In each of the models (Models 1 to 3), women have fewer DS than men. In Model 1, controls for age, a non-English interview, and rural residence and living in the South have the expected effects. These effects, however, become insignificant when education and income are added to the model (Models 2 and 3). This indicates that race-ethnicity differences in DS are largely a result of differences in SES.

Increased levels of income and education are associated with better dental health, but as expected, the effects of these variables diminish when we control for annual dental care and health-related behaviors. As we anticipated, going to the dentist at least once each year significantly improves dental health. Smokers have more DS, but past smokers have fewer. We suspect that selection into the population of respondents who have quit smoking may be indicative of unmeasured factors associated with superior dental hygiene. Finally, when we control for the other factors affecting dental health, sugar and alcohol consumption are insignificant. Thus we find no evidence for the theory that the poor have more tooth decay because they smoke more and consume excessive amounts of sugar and alcohol. Although controlling for education substantially diminishes the race-ethnicity effect for Blacks, controlling for health behaviors does not produce any appreciable reduction in the Black-White gap.

In Models 4 to 6, we examine the factors that increase or decrease the likelihood of having MS. As noted previously, MS is an indication of low-cost dental care rather than dental morbidity. It simply costs less to extract teeth than it does to perform more rehabilitative dental repairs. Thus we expect that many of the same factors that increase the probability of dental decay will have a similar impact on the likelihood of having tooth surfaces that are missing. Overall we find that our expectations are met. Blacks are much more likely than Whites to have MS, net of the other variables in Models 4 to 6. The absence of any difference between Mexican Americans and Whites in their number of MS observed in Table 2 for the population younger than sixty-five persists, even when we control for exact age of the participant. Nevertheless, although the coefficient for Mexican Americans is not

significant, we do find that those respondents who had a non-English interview had significantly fewer tooth surfaces. Because almost all of the non-English interviews were conducted in Spanish, it is very likely that the effect of language is picking up an important effect of stratification within the Mexican American community. When we control for age, Mexican Americans who are recent immigrants, and therefore less fluent in English, are more likely to have their teeth extracted (versus having their teeth repaired) than those Mexican Americans who were able to communicate with the NHANES interviewers in English. Thus we find a similar pattern in Models 4 to 6 for Blacks and for Mexican Americans who lack English-language skills.

One key difference between the models for MS and those for DS pertains to sex. Women have far fewer DS than men, net of other variables. This sex difference, however, is absent in the MS models. It is not surprising that those who live in rural areas are more subject to dental extractions than those living in urban or suburban areas. This difference, however, also becomes insignificant when we control for SES and health-related behaviors. As with tooth decay, income and education have the expected effects, but these effects appear to be more direct and are less likely to be mediated through dental care and health-related behaviors.

### Interaction Effects

Given the strong relationship of untreated dental problems to race-ethnicity and SES, as well as the strong impact of untreated dental decay on overall health and well-being, our analysis of interaction effects is focused on the measure of untreated dental decay. Table 4 presents the full model for dental decay, where the sample is stratified by income and by race-ethnicity. The first two models of Table 4 address the possibility that race-ethnicity and SES interact so that poor and less affluent Blacks and Mexican Americans are more at risk than would be expected from the additive effects of race-ethnicity or SES alone. These models show results for respondents living in families with incomes higher than and less than the median. If minorities in lower income groups have a greater risk of dental decay, we should find larger coefficients associated with race-ethnicity in the models for participants in the lower half of the income distribution and much smaller coefficients in the upper half. In fact, we find the opposite. The Black-White difference in the number of DS, net of other variables, is greater for Blacks in the upper half of the income distribution than it is for Blacks in the lower half of the income distribution. This finding is quite unexpected, and the reason why affluent Blacks would have more dental decay relative to Whites (net of other variables) than less affluent Blacks is not entirely clear.

Although both components of SES continue to have a beneficial effect on tooth decay, the relative importance of each is different for the different income groups. The poor and less affluent appear to benefit more from increases in income, whereas the affluent benefit more from education. As expected, we find that annual trips to the dentist result in fewer DS for both income groups, but the benefit is greater for those in the upper half of the income distribution. The poor who receive dental examinations may simply be less able to afford the rehabilitative

**TABLE 4**

Weighted Poisson Regression of Decayed Tooth Surfaces by Family Income and by Race-Ethnicity

| | *Respondents Aged 17 to 65* | | | | |
|---|---|---|---|---|---|
| | *National Health and Education Study III* | | | | |
| | *Family Income* | | *Race-Ethnicity* | | |
| | *Below Median* | *Median or Above* | *White* | *Black* | *Mexican American* |
| Intercept | 1.1714*** | 0.1339 | 1.2039** | 1.2297*** | 0.2779 |
| Age | 0.0019 | 0.0046 | –0.0011 | 0.0048 | 0.0175*** |
| Female | –0.1505 | –0.4339 | –0.3557* | –0.1371 | 0.0635 |
| Black | 0.2736* | 0.8356*** | | | |
| Mexican American | –0.1786 | 0.5368 | | | |
| Other | –0.2635 | 0.7016 | | | |
| Non-English interview | –0.0944 | 0.0429 | 0.6846 | –1.5189*** | 0.1316 |
| Rural | –0.0992 | 0.3553 | –0.0116 | 0.0309 | –0.0487 |
| South | 0.2157 | 0.1148 | –0.0072 | 0.4530*** | 0.2447* |
| Less than high school | 0.3589** | 0.0532 | 0.4283* | –0.0420 | –0.0296 |
| Some college | –0.1745 | –0.3186 | –0.1910 | –0.1166 | –0.2519 |
| College degree | –0.6612** | –0.7951** | –0.7755*** | –0.6787*** | 0.2015 |
| Income to poverty ratio | –0.2098** | –0.0668 | –0.1927* | –0.1721*** | –0.1434* |
| Dentist once per year | –0.8591*** | –1.3877*** | –1.2031*** | –0.7410*** | –0.9182*** |
| Smoker | 0.3263** | 0.6910** | 0.5854** | 0.2486** | 0.3986*** |
| Past smoker | –0.4176* | –0.0832 | –0.3267 | 0.0020 | 0.0038 |
| Sugar consumption | 0.0007 | 0.0043* | 0.0014 | 0.0005 | 0.0014 |
| Alcohol consumption | 0.0001 | –0.0033 | –0.0039 | 0.0028* | 0.0032 |
| Model *N* | 7,068 | 3,350 | 3,544 | 3,364 | 2,961 |

*Note:* Models are adjusted for design effects and unequal probability of selection.
*$p < .05$, **$p < .01$, ***$p < .001$.

procedures than those respondents from more affluent families, even if they see the dentist at least once a year. This might also explain why we find that increases in income among the less affluent have a positive effect on dental health that is not seen among those with incomes higher than the median. Smoking has a negative effect for both groups, but the effect is worse for those with more income. The benefit associated with those who have quit smoking, observed in Table 3, appears only for those with family incomes less than the median. Finally we do see some evidence for the negative effects of sugar consumption, but contrary to the stereotype, we find this effect among the middle-class rather the poor.

In the last three models of Table 4, we examine the extent to which measures of SES and the other variables included in our models have on tooth decay within three of the race-ethnic groups. We find that the female advantage seen in Table 3 is present only for White women. The positive coefficient for a non-English interview in the model for Blacks results from the inclusion of two Spanish-speaking Black respondents with very good dental health. We find that both Blacks and Mexican Americans who live in the South have more tooth decay than those who live elsewhere, a pattern not observed for Whites. Having a college degree is associated with better dental health for Whites and Blacks but not for Mexican Americans. Annual dental care has a positive effect for all three groups, but the effect is greatest for Whites. And finally, we do see the negative effects of alcohol use but only among Blacks.

## SUMMARY AND DISCUSSION

The results of our analysis of the NHANES III data indicate that there are strong race-ethnic differences in dental health. When we examine the numbers of DS and MS, we find that both Blacks and Mexican Americans have substantially more DS than Whites. Multivariate models, which control for the exact age of the participant and for the language used in the interview, show that these minorities are also more likely than Whites to have MS, net of the effects of other variables. Among those younger than sixty-five, Blacks have by far the greatest level of dental morbidity, with two and a half times as many untreated DS than Whites and 49 percent more DS than Mexican Americans. The total MS, an indicator of previous morbidity treated with extraction, reveal a similar pattern.

Our multivariate analysis has yielded several important findings. First racial and ethnic differences in the number of DS and MS cannot be fully explained, either by differences in SES or by differences in annual dental care and health-related behaviors. To be sure, SES does reduce the direct effects of race-ethnicity on dental outcomes. Similarly, annual dental care and health-related behaviors explain some of the positive effects associated with increased levels of income and education. Nevertheless the effects of race and ethnicity remain strong and significant, even when controls for SES, dental care, and health-related behaviors are included in the model. Reid et al. (2004) found that "material factors" play a greater role than "behavioral factors" in mediating the effects of race-ethnicity. This study extends that research by showing that (a) SES mediates some portion of the effects associated with race and ethnicity and (b) dental

care and health-related behaviors mediate a portion of the effects associated with SES.

Further research is needed to fully understand why these race and ethnic differences in dental health persist, even when controlling for a host of relevant factors. Previous research suggests that minorities tend to use dental services on a symptomatic basis, which could result in overall poorer health (Garcia and Juarez 1978). Another important factor may be attitudes toward dental care. One study of older adults found that negative attitudes toward dental care explains some of the race and income differences in dental health; many of those with the highest levels of dental need do not seek care because of these attitudes (Gilbert, Duncan et al. 2003; Gilbert, Duncan, and Vogel 1998; Gilbert et al. 1997, Gilbert, Duncan, Heft et al. 1998; Gilbert, Shelton et al. 2003). Although our study controls for annual dental visits, a more precise, valid, and reliable measure might be needed to capture race-ethnic differences at the level of actual dental treatment received.

One unexpected finding from our study is that for Blacks race has a larger negative effect for those respondents who are relatively more affluent. We expected the opposite would be true. Moreover, because our models control for both income and routine dental care, this finding is hard to explain. We suspect that the larger Black-White gap among the affluent may arise from unmeasured differences in health-related behaviors or from differences in the quality of dental care currently received. Another possible explanation is that our cross-sectional data do not capture the cumulative effects of access to dental care throughout the life course, access that may very well vary by race, even among those who at the time of the survey were similar with respect to SES and current dental care. But in the absence of more information, we cannot be certain about the reason for this finding.

Perhaps the most robust discovery in our study is that cigarette smoking results in both tooth decay and a loss of tooth surfaces. This appears to be true regardless of age, income, or race-ethnicity. Although those who quit smoking appear to have a dental advantage, it is likely that selection factors, or other variables associated with quitting, account for this effect. These results should not be interpreted to mean that smoking and then quitting confers some advantage over not smoking at all.

Finally our study shows that relatively poor dental health of minorities and the poor cannot be accounted for by differences in smoking and health-related behaviors, such as cigarette smoking, sugar consumption, and alcohol use. Although these variables do appear to mediate some of the effects that income and education have on dental health, they appear to mediate very little of the race-ethnicity effects once we have controlled for both dimensions of SES. Our results show that the strong racial-ethnic and socioeconomic differences in dental health persist even when controlling for health habits, monetary resources, and regularly visiting the dentist. The findings from this study suggest that policies to promote better dental health should focus on both consumers and the world of practitioners. Specialists in public health dentistry point to the important role of oral health education in developing better dental health (Frazier 1992). Our findings show that variables that influence untreated dental problems vary from one demographic

subgroup to another. Effective oral health education programs could be designed to meet the specific needs of target groups.

Although oral health education efforts should focus on dental consumers, other policy efforts and research should focus on the supply of dental health practitioners. Recent research has documented the existence of a health care system that is highly segregated by race-ethnicity, with African Americans much less likely than others to have access to high-quality care (Bach et al. 2004). The situation may be even more serious within dentistry, for there are fewer minority dentists than minority physicians.[7] Increasing the supply of minority dentists could help improve both access to dental care and its use. Moreover it is equally important that we remove barriers that prevent minorities from seeking and using dental health care that is now available to the White community. Although oral education is important, what low-income and minority adults need most is greater access to preventative and opportune health care.

Social scientists should continue to analyze dental health. Future research should include Hispanic groups other than Mexican Americans as well as more detailed measures of dental health habits and behaviors. It should also give more attention to oral health functioning and appearance (see Gilbert, Duncan, and Vogel 1998; Gilbert, Duncan, Heft et al. 1998). Most important, these studies should focus not only on how SES contributes to dental health but also on how dental health contributes to social mobility and the role it plays in perpetuating inequalities and status differences.

## NOTES

1. The term *oral health* is more all encompassing than the term *dental health*. *Oral health* generally refers to all elements of the mouth and jaw, whereas *dental health* tends to refer to only teeth and gums. We use the terms interchangeably because the two conditions are very much interrelated.
2. We focus on tooth surfaces instead of whole teeth, as the former provides a more precise measure of untreated caries.
3. The measure of DMFS includes decayed permanent surfaces, permanent filled surfaces, surfaces missing because of caries or disease, and surfaces replaced because of caries or disease. Our measure of MS includes only those surfaces missing because of caries or disease. Surfaces that are missing or replaced because of orthodontia or accidents are not included in either measure (DMFS or MS).
4. People who are edentulous are included in both measures (MS and DS). Note that if a surface has been replaced, it is included in the DMFS count but not in the DS or MS counts. To control for the strong relationship of age to edentulousness, we conduct separate analyses for respondents sixty-five and older and those younger than sixty-five.
5. Alcoholic beverages include wine, wine coolers, sangria, champagne, and hard liquor, such as tequila, gin, vodka, scotch, whiskey, and liqueurs. Sugar items include cakes, cookies, pies, doughnuts, pastries, chocolate candy, fudge, Hi-C, Tang, Hawaiian Punch, Kool-Aid, vitamin C drinks, diet and nondiet colas, sodas, and drinks.
6. The measures of dental health used in the analysis, DS and MS, are discrete, nonnormally distributed count variables that approximate a Poisson distribution.

7. Data from the 1990 census (the census year occurring closest to the time of the NHANES III) indicated that 80.5 percent of all physicians and 88.7 percent of all dentists were White, 4.9 percent of all physicians and 2.6 percent of all dentists were Hispanic, 3.6 percent of all physicians and 3.1 percent of all dentists were Black, and 11.0 percent and 5.7 percent of all dentists were classified as Other (U.S. Bureau of the Census 2004).

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